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Testing the Weak-Form Efficiency of Ukrainian Stock Market

by

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Biographical Note

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Abstract

Much attention has been recently paid to examining speculative stock markets of East-European economies. This study aims to make a contribution to the previous scarce empirical research on the efficiency of Ukrainian stock market, which has focused on testing the weak-form efficiency mostly during the years much preceding the global financial crisis and claims controversial results. Therefore, to test the weak-form efficiency of PFTS, the main Ukrainian stock exchange, during 2009-2015, ARMA and GARCH models are applied, a methodological approach that has proved to be effective and widely used for highly volatile stock markets. The findings suggest that Ukrainian stock market during the tested period tended to be inefficient. The conclusions might be of interest and importance for domestic and foreign investors and traders when making investment decisions, as well as for authorities, responsible for policy making decisions and reforms implementation in the financial sector.

Key-words: emerging stock market; weak-form efficiency; ARMA; GARCH

JEL-Codes: C12, G14, G15

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1. Introduction

Proper resource allocation, boosting investment into the economy, developing corporate control market and promoting overall economic growth are some of the main advantages claimed about well-functioning stock markets. Therefore, given their important role in the financial system and in the overall economy of the developing countries, it is essential not only to analyze the recent development progress and improvements, but also to identify to what extent is the equity market efficient. Based on the 'capital market efficiency' concept, developed over the last century, the equity markets of former Communist East-European countries have been vastly examined and tested with most all available methodological approaches. However, there is still a lack of agreement on the Ukrainian stock market efficiency and a gap in the research on the post-crisis period.

Therefore, the present study aims to examine the weak-form efficiency of the Ukrainian stock market in the subsequent years after the global financial crisis. Following the example of the studies on neighboring countries, the most similar in terms of market capitalization and stage of development, autoregressive integrated moving average and stochastic volatility modeling is chosen as a methodology. Consequently, using the data on the PFTS stock Index of the biggest Ukrainian stock exchange during 2009-2015, ARMA with GARCH models are applied to test the weak-form of the EMH.

Besides this section, this dissertation is structured in the following way. Section 1 provides for an introduction. In Section 2, a literature review of the topic is made. In section 2.1 and 2.2 the development of the 'capital market efficiency' concept, its implications and the relevant studies are presented respectively. Section 2.3 sums up with the critical analysis of the reviewed literature. Section 3.1 gives an insight into the benefits of efficient stock markets realized for the developing economies. Section 3.2 overviews the interdependent processes of establishment of the stock market and privatization in Ukraine. Section 4 covers the methodological aspects of this study, with section 4.1 focusing on data collection and data sample, while in section 4.2 the statistical approach and the model are clarified. This is followed in Section 5 by the research findings discussion, and the dissertation finalizes with the conclusions and suggestions for the future research.

2. Literature Review

The development of the Efficient Market Hypothesis, as one of the most fundamental concepts in finance, has set up the basis for determining stock market prices formation and behavior, aroused interest and determined research efforts in national stock markets' behavior worldwide. Particular interest has been paid to the development and movement of equity markets towards higher informational efficiency. Therefore, this section presents an overview of the 'capital market efficiency' concept birth and development, the relevant studies and the implications for the current research.

2.1. Capital market efficiency concept development

Any information that determines future stock performance should already be reflected in current stock prices. Once there is information on profit opportunities with regard to underpriced or overpriced stock, the demand for it driven by well-informed and rational investors would push the price back to the fair value. Given all the available information and fair value at the moment, the decrease or increase of the stock price, therefore, should occur only with the arrival of new information. Thus, stock price changes follow an unpredictable and random pattern, which is the natural result of all current available information and the basis of the 'random walk' concept. Otherwise, the ability to predict price movements would indicate that all available information is not reflected in current securities' prices and that the stock market is not well-functioning and inefficient. Hence, it would contradict the *efficient market hypothesis*, under which security prices at any time fully reflect all the available information (Fama, 1970a).

Besides, three main conditions are defined to ascertain capital market efficiency, and therefore, full reflection of all available information in the security's current price. Firstly, it is the absence of transaction costs in securities trading; secondly, that all market participants possess all available information at no cost; thirdly, that there is a common consensus on the implications of current information for the current price and distributions of future prices of the securities (Fama, 1970a). However, these conditions are sufficient for well-functioning market, but not in all cases necessary. Even with large transaction costs, taking into account all the available information for the transaction parties, still this could be consistent with all available information being reflected in the fair value of securities. Notwithstanding, the violations of any of the aforementioned conditions are referred to as "potential sources" for market inefficiency and, apparently, may exist to some extent in reality in the capital markets. For instance, the stock markets of Kazakhstan, Bulgaria, Hungary, Czech Republic, Georgia, Estonia, Lithuania, Moldova, Latvia, demonstrating to some extent the violations of the conditions of equal access to information by the participants and transaction costs' absence, proved to be inefficient during the period 2008-2010 as systematic abnormal earnings could be obtained with the use of proper instruments (Dragota & Tilica, 2012).

It is very common to distinguish different versions of market efficiency according to the adjustment of security prices to all available information: the weak, semi-strong, and strong hypothesis' forms (Fama, 1970a). The *Weak-form* refers to the security price reflection of all information that can be derived from past history of volumes and prices. If available and costless information can be obtained which could help to anticipate future security performance, such a profit opportunity would be exploited by investors and therefore would tend to disappear. The *semistrong-form* considers the speed of adjustment of all publicly available information in the stock price with regard to the firm prospects. For example, announcements of stock splits, annual results, accounting practices, patents, earnings forecasts, etc., are all fundamental data that should also be available to all participants of the market and immediately reflected in stock prices. Under the *strong-form*, all the relevant information about the firm, even the one which is available only to the company insiders, should nonetheless also be reflected in the stock price. Despite the arguments on whether the corporate officers are able to derive advantage for themselves by trading before public releases, the existing regulations are directed at preventing the insiders from profiting through their privileged access to information. For instance, Rule 10b-5 of the US Security Exchange Act of 1934 imposes limits on trading by the directors, corporate officers and owners, who are required to report trades to the Securities and Exchange Commission. If the market is efficient in the strong form, it entails its efficiency also in the semi-strong and weak forms. Therefore, the aforementioned three forms determine the level of information, at which the efficiency hypothesis no longer holds (Clarke et al, 2001).

The market efficiency theory has its origins in "fair game" models and dates back to the studies of Bachelier (1900) of the first random walk model testing, which implied one of the fundamental principles of martingale, but it was translated completely from French into English only 64 years after, and therefore not widely known back then. Working (1934) and Cowles & Jones (1937) examined the predictability of prices through a probability approach. The scientific studies in the 1920-40s entailed technical and fundamental analysis and mostly came to the conclusion that security' prices patterns seemed to contradict the "random walk" hypothesis (Batorshyna, 2006). Kendall (1953) substantially modified the probability model and found strong support for Working's empirical results. Samuelson (1965) and Mandelbrot (1966) also studied efficient market theory in relation to the "fair game" expected returns models. In 1970 Eugene Fama stressed that previous research attempts failed short only "in awareness of developments in the theory of stochastic processes" and came up with the conclusion that American capital market complied with the market efficiency conditions (Fama, 1970a, p.391).

The formal foundations of EMH, established by Fama, were further examined and developed in the works of Rubenstein (1975), Lathem (1986) etc. However, some research presented results which were less consistent with earlier findings, namely with some evidence on the predictability of futures stock prices consistent with behavioral and psychological based theories. Some researchers came up with the conclusion that the inability of statistical testing to reject the EMH did not imply the markets being inefficient (Summers, 1986). Growing evidence on systematical markets deviations began to appear more and more in the studies of De Bondt, 1985; Kahneman and Tversky, 1982; Thaler, 1987; Jegadeesh and Titman, 1993; Lakonishok et al., 1994; Shiller etc. January, weekend effects, equity premium puzzle and other anomalies, at odds with all rationality-based theories, contributing to the formation of the field of behavioral finance.

Clearly, such evidence on persistent irrational behavior reflected in stock prices was contrary to the market efficiency theory of Fama, who referred to the findings in behavioral finance as contradictory with each other, and after all, embracing a collection of anomalies that could however be compatible with the market efficiency hypothesis (Fama, 1998b). Notably, despite apparently opposing theories on how the financial markets function and asset pricing, Schiller and Fama together shared the Nobel Prize in Economic Sciences in 2013.

All in all, the evidence against EMH cannot be neglected and, indeed, indicates directions for further research. The empirical evidence provides enough examples of the anomalies to justify the mispricing of securities retrieval and apparently continues to thrive. However, the market is competitive enough to bring easy pickings to naught and differentially superior insight and strategy are necessary to strive to beat the market. The EMH serves as one of the most fundamental concepts in finance and, in particular, stock market behavior framework. Despite the abundant empirical evidence on market inefficiency at particular periods and markets, it tends to be more often consistent with the efficiency hypothesis rather than with the inefficiency alternative. Therefore, one can rightly claim that the more relevant question today is not whether the markets are efficient, but rather how efficient the markets are.

2.2 Relevant studies

The debate over the "market efficiency" has given a boost to subsequent research on national stock markets worldwide. However, recent empirical studies have focused more on the capital markets of emerging stock markets rather than on well-developed ones.

For instance, Karemera et al.(1999); Ammermann and Patterson (2003); Lim and Hinich (2005); Charles and Darné (2009) contributed to the research on the Asian capital markets efficiency, while in Latin American markets the studies are represented by Karemera et al. (1999), Bonilla et al. (2008), Kim and Shamsuddin (2008) and Espinosa et al. (2013). African markets were examined in the studies of Asal (2000), Smith and Jefferis (2002), Appiah-Kusi and Menyah (2003), Mlambo and Biekpe (2007), Ntim et al. (2011), Kampanje (2012) among others.

However, of particular interest to researchers are the speculative stock markets of Post-Communist block of countries. In the context of short independent history and with the implementation of reforms and financial incentives for foreign investors, testing EMH for national capital markets has been aimed at finding evidence on an improvement in the efficiency level and in the determination of restraining factors, and on developing recommendations for helping the development of those economies. The methodology with regard to testing EMH and the random walk hypotheses has been substantially amplified throughout these years. Table 1 demonstrates the variety of methods and statistical techniques used in numerous studies on East-European stock markets.

Table 1 – Testing techniques on market efficiency of former Communist East-European countries

Methodology	Authors/ Studies	Markets	Time
Autocorrelation tests (ACF, aLjung-Box, LMb)	Dezelan (2000) Worthington & Higgs (2004), Dritsaki (2011)	Slovenia – Czech Rep – Hungary + Poland +	1994-1998 2003 2007-2010
BDS test	Lazar & Ureche (2007)	Czech Rep –	1995-2007
Nonlinear analysis	Omay & Karadagli (2010)	Bulgaria +	2002-2010
Unit root tests	Dima & Milos (2009) Omay & Karadagli (2010) Stancu & Predescu (2010) Dritsaki (2011)	Romania + Romania + Romania + Slovakia +	2000-2009 2002-2010 1997-2009 2007-2010
Multiple Variance Ratio (MVR)	Smith (2012) Guidi et al. (2011)	Czech Rep + Estonia – Bulgaria – Latvia + Lithuania + Bulgaria – Poland – Czech Rep –	2000-2009 1999-2009
Runs testing	Dezelan (2000) Dima et al. (2006) Omay & Karadagli (2010)	Slovenia – Romania – Bulgaria +	1994-2008 2004-2005 2002-2010
Day-of-the-week effect (DOW)—Monday effect	Codirlasu (2000) Yalcin & Yucel (2006) Zikes & Bubak (2006) Stoica & Diaconasu (2011)	Bulgaria – Hungary + Montenegro Croatia – Macedonia –	2000-2005 1997-2004 2003-2009 2000-2010

Month-of-the-year effect, End-of-month effect, Holiday effect	Heininen & Puttonen (2008) Gakhovich (2011)	Bulgaria + Czech Rep – Croatia – Hungary – Latvia – Bulgaria – Hungary – Latvia – Lithuania – Serbia –	1997-2008 2010
Stochastic volatility models (GARCH models)	Gordon & Rittenburg (1995) Emerson et al. (1997) Hall et al. (1998) Rockinger & Urga (2000) Harrison & Paton (2005, Zikes & Bubak (2006) Yalcin & Yucel (2006) Zalewska-Mitura & Hall (1999a)	Poland – Bulgaria – Russia – Czech Rep – Hungary + Russia + Romania + Hungary – Czech Rep – Slovenia – Hungary +	1993-1994 1994-1996 1997 1994-1999 1997-2002 1997-2004 1994-2005 1998
Return breakdown model	Pele & Voineagu (2008)	Romania +	1997-2007
Evolving efficiency model	Zalewska-Mitura & Hall (2000b)	Hungary +	1998
Trading rules, Filter-rules	Codirlasu (2000), Chong et al. (2010)	Romania – Russia –	1998-2000 1995-2008
ARIMA (Box-Jenkins); ARIMA - GARCH	Stancu & Predescu (2010) Abrosimova et al. (2002) Fedorova (2009)	Romania – Russia + Russia -	2002-2010 1995-2001 2001-2007
Hinich–Paterson	Todea & Zoicas-Ienciu (2008)	Czech Rep –	1995-2006
Simulations, Generalized spectral test	Posta & Hackl (2007) Todea & Lazar (2012)	Czech Rep + Czech Rep +	2003-2004 1999-2009

Source: based on Dragota & Tilica, 2013, p.319-320
Note: (–) means inefficient stock exchange; (+) stands for the EMH couldn't be rejected

In recent years, the attention of researchers has turned to Ukraine as well. One of the first articles, published on the Ukrainian PFTS stock index performance during 2001-2005, confirmed, in general, the weak-form efficiency of the equity market, with only 2003 not falling under conditions of informational efficiency (Batorshyna, 2006).

However, all the subsequent research has found contrary results. Dragota and Tilica (2013) also based on the PFTS stock index returns between January 2008 and December 2010, carried out several tests, in particular, runs test, variance ratio test, filter rules, and focusing on the January effect concluded that the stock prices did not follow a random walk thus rejecting the weak form of EMH. Smith in 2012 examined fifteen European emerging stock markets, comparing these to the UK, Portugal and Greece stock markets' efficiency. During a tested period between 2000 and 2009, due to the rolling window variance ratio tests results, Ukraine along with Malta, Estonia and Iceland fell under the category of the least efficient markets. No progress towards greater informational efficiency characterized these stock markets. Espinosa et al. (2014) applied a Hinich test to six stock markets including Ukraine within 2000-2010. The main conclusions concerning the "window size effect" implied an increase of the rejection hypothesis with the size of the window and the weak-form of the EMH was not confirmed, which is consistent with the former research findings. Khrapko (2013) used statistical tests such as the Mann–Kendall, Bartel test, inversions, up-and-down and simple runs tests, and failed to reject the weak form of the EMH, while only the Lo–MacKinlay variance test did not confirm the null hypothesis. Table 2 sums up all the studies' contributions into the research on Ukrainian equity market.

2.3. Critical analysis of the literature reviewed

Numerous studies with the usage of various methodological approaches have been carried out on the East-European equity markets. It is noticeable that recent research has strongly focused on GARCH modeling, which is regarded by many researchers as relatively easy to apply and more advantageous over the other approaches in testing the weak-form efficiency of highly volatile stock markets (Kampanje, 2012; Orabi, & Alqurran, 2015). As long as this class of models enables to obtain a precise estimate of the conditional volatility of financial instruments (Ahmed & Suliman, 2011). Nevertheless, ARIMA modeling, known also as Box-Jenkins approach, is also widely used in financial forecasting and recognized for distinguished forecasting accuracy and flexibility relative to different types of time series (Khandelwal, 2015; Adebiyi, 2014; Pai & Lin, 2005). Their only limitation is based on the linear form, which does not fit the complex modelling of nonlinear time series (Khandelwal, 2015). Therefore, ARIMA models are often applied along with GARCH (ARCH) ones, in particular, when testing stock market efficiency (Abrosimova et al., 2002; Fedorova 2009; Arora, 2013). Properly fitted models of ARIMA and GARCH enable to identify how in a certain way the observations, variance and noise have an effect on the subsequent values of the time series, and hence have sufficient predictive utility (Abrosimova et al., 2002).

Table 2 – Studies concerning Ukrainian stock market efficiency testing

Year	Authors	Country(-ies)	Data	Methodology	Results
2006	Batorshyna	**Ukraine**	2001-2005	Irvin method	2003 defined as inefficient. While, the weak-form of EMH confirmed for the rest of the years
2012	Smith	Croatia, Czech Republic, Estonia, Hungary, Iceland, Latvia, Lithuania, Malta, Poland, Romania, Russia, Slovak Republic, Slovenia, Turkey and **Ukraine**	Feb 2000-Dec 2009	Rolling window variance ratio tests	among four least efficient markets
2013	Dragota & Tilica	Bosnia-Herzegovina, Bulgaria, Croatia, CzechRepublic, Estonia, Georgia, Hungary, Kazakhstan, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, **Ukraine**	Jan 2008-Dec 2010	unit root tests, runs test, variance ratio test, filter rules test and the January effect	the weak-form of EMH rejected
2013	Khrapko	USA, Russia, Poland and **Ukraine**	Aug 2008 - Oct 2011	Mann–Kendall, Bartel inversions, up-and-down and simple runs and Lo–MacKinlay variance tests	all except for Lo–MacKinlay variance test confirmed the weak-form of EMH

2014	Espinosa, Gorigoitia, Maquieira & Vieito	Bulgaria, Hungry, Poland, Russia, Serbia, **Ukraine**	2000 -2010	Hinich test	the weak-form of EMH not confirmed

However, Ukraine appears to be among the least examined countries, questioning the solidity of existing knowledge about the efficiency of the Ukrainian stock market, in particular, in the aftermath of financial crisis 2007-2008. Only a few authors have examined the weak-form efficiency hypothesis of the stock market in Ukraine, mostly in comparison to other neighboring economies, and all based on the stock index performance during the pre-crisis period and with the use of many methods, but not stochastic volatility models and hybrid ARIMA-GARCH modeling, which serves a good methodological framework for testing the weak-form market's efficiency. Besides, there were already contradictory results and conclusions, all in all, making this topic a relevant research opportunity in Ukraine. Therefore, the question of the extent of the informational efficiency of Ukrainian stock market in the years following the financial crisis up to now, justifies the need for this new study.

3. Stock Market Particularities in Ukraine

3.1. Role of an efficient stock market in transition economies development

An underdeveloped financial system puts a lot of limitations on the corporate sector to access to long-term funds, which is essential to stimulate production, national economic activity and development. Under these conditions, it becomes extremely important for households and firms to seek for other ways to mobilize savings, diversify and efficiently allocate investment resources. Therefore, a well-functioning financial system, which is to a great extent reliant on the stock market, is crucial in a country's economic development. In recent years, it has been of great interest to the academic researchers to examine and present explicit evidence on the financial economic development and the implications of well-functioning stock markets in terms of savings growth, efficient allocation of investment resources promoting domestic and foreign investment.

The pricing process mechanism is crucial to the allocative function of the market. Well-managed and profitable firms are rewarded in an efficient market in the form of a higher stock valuation than those performing much worse. This is supposed to give an access to a lower cost of capital for the former and, therefore, enable greater investment resources allocation to well-performing companies at the cost of less performing ones (Singh, 1993). Once the funds are allocated to the most valuable investments projects and companies in the economy, capital allocation is considered to be efficient, which is the main role of financial institutions.

The "Stanford school" is associated with studying the relation between long-term economic growth and capital market development (McKinnon, 1973; Shaw, 1988). According to these authors, "liberalization of a repressed market" through growing monetarization and intermediation of the economy, bringing the interest rates to the fair levels, will promote economic development. Atje and Jovanovic (1989) claim that the faster the countries manage to develop their stock markets, the better they speed up their economic development. The possibility of a positive correlation between economic growth and financial development was further examined and supported by King and Levine (1993). Bekaert et al. (1997) extended the positive impact of efficient stock markets to the whole economy in the form of a productivity increase through the mitigation of moral hazard problems at corporate level (contingent, however, on the size of the stock market value relative to GDP).

In addition, efficiency of a stock market to some extent promotes entrepreneurship and once again overall long-term productivity, as long as transaction costs are not too high and there is less uncertainty about acquiring securities at fair prices in the stock market. The efficient markets set up the conditions for new enterprises to raise capital more easily, for example, through initial public offerings (Bekaert & Harvey, 1995).

On the other hand, Singh (1993) places in doubt whether all the aforementioned implications of efficient stock market do actually imply in practice an inevitable economic growth of the transition economies and suggests attempting to foster bank-based rather than stock-markets financial systems. The arguments in favor of such industrial development promotion are given using the examples of Japan, France and Germany. According to the modern theory of information, banks in comparison to the shareholders of corporations have both the incentive and means to collect information, monitor and make an adequate opinion on long-term companies' prospects. However, successful industrialization of developing economies in this scenario is feasible along with a grand range of macroeconomic and political restructuring provided that there is a proper regulation and a non-monopolistic bank system. In addition, as long as the formation of stock markets takes place in developing countries along with other structural transformations, their firmer establishment and maturing would affect corporate control market development.

Characteristically for many transition economies, privatizations became a central pillar in building a market economy, where a stock market quite often played an important role in accelerating that process (Estrin, 2007). Along with structural reforms, privatization experiences enable in many cases further economic development. As, for example, transition of ownership rights trough the sales in the stock markets in many countries enabled to expand and develop capital markets (Tanko, 2004). The total capitalization of the world's stock markets increased elevenfold from \$3.4 trillion to \$38.7 trillion during 1983-1999 thanks to the share issue privatizations (Megginson & Boutchkova, 2005).

To sum up, stock market efficiency tends to be of great importance in developing economies with regard to allocation of investment resources efficiently to more profitable projects and firms, raising capital in corporate sector, boosting domestic and foreign investment into the economy, developing corporate control markets, which in its turn, can play an essential role in developing the financial system and promoting overall economic growth.

3.2. Privatization and stock market development in Ukraine

The stock market development in Ukraine to a great extent took place as a consequence of a privatization program, in particular, following auctions of privatized enterprises and occasional stock trading on ownership redistribution processes, which in its turn, prompted the entry of traders to national securities markets. Therefore, it is important to follow the track of ownership relations for a better understanding of the Ukrainian financial market formation.

Privatizations along with generating revenues for the state are regarded as bringing improvements in corporate efficiency. Through the transformation of state owned assets into privately owned, firm performance tends to improve with less politicized business decisions, more effective corporate control placed on managers through internal constraints and monitoring by the owners (Vickers & Yarow, 1985; Estrin, 2007). Upon independence on 24 August, 1991, Ukraine faced the need for cardinal structural reforms, including transformation of the largely inefficient huge public enterprise sector.

The purpose of privatizations in Ukraine, initiated in 1992, was to transform the country from a centrally planned to a market-based economy, through an increase in the private-sector share of the economy and by attracting strategic investors. Like in many other former Soviet Union countries, in Ukraine domestic ownership was common. Moreover, Ukraine did not appear to be among the countries like Hungary, Czech Republic and Poland, with dominant foreign direct investments flows, which enabled them to boost their economic development (Meyer, 1998; Estrin, 2007).

However, considering the scale of the privatization process, three important periods can be outlined. During 1992–1994, though unfolding at a modest pace, ownership transfers took place in the form of entire property complexes leasing by the enterprises' employees. Completely or partially, 11,000 companies were privatized, mainly in the light and food manufacturing sector industries.

The 1995–1998 phase became the most important one, with almost 70% of all the state industry sector privatizations, accounting for 70,526 companies, being implemented. Since 1995, with the mass privatization program unfolding, privatization vouchers were introduced. Ukrainian citizens could exchange those securities for stock of state enterprises at special privatization auctions. The owners of such certificates could apply to buy the shares of any company, auctioned each month. Moreover, each applicant's stake was influenced by the total number of applicants for that same company. Therefore, by the end of this period, privatization auctions enabled the stock market to attain a critical mass and over-the-counter trading started. Nevertheless, such approach failed to set up effective corporate governance systems in most firms and resulted in the abuse of the rights of minority shareholders. While most of the population strived for a living in harsh economic conditions and sold their certificates before the auctions, investors and companies who had money used the opportunity to purchase the companies at really low prices, and, as a result, obtaining a strong influence in company management (Bleyzer et al., 2005).

The third phase can be referred to 1998 and post years, when the firms were mostly privatized through tenders in the stock exchange in monopolistic and strategic sectors, such as metallurgy, electricity distribution, petrochemicals, and telecommunications, which aimed not at strategic investment but rather at raising revenue for the state.

It is important to take into account that since the beginning all macroeconomic factors were unfavorable for financial markets formation and its successful development. Independent Ukraine, with an economy highly dependent on other former Soviet Republics, an industrial sector extremely energy intensive and an uneven implementation of economic reforms, amplified by a lack of political consensus, experienced a recession with a cumulative decline of about 60% of GDP within 1991-1999. During 1992–93, the fiscal budget deficit reached 25% and 16% of GDP, respectively. Monetary financing of these deficits led to high annual rates of inflation, which peaked at 2,609% annual average for 1992, over 1,000% in 1993, and remained above 100% per year consecutive two years (Bleyzer et al., 2005).

All these economic and political conditions put the brakes on the equity market, which officially was set up on 28 October 1991, the same year Ukraine became independent, but basically did not evolve until the aforementioned privatization auctions in 1995-1996. The first stock exchange created in Ukraine was named as the Ukrainian stock exchange (USE), which is still operating among nine more stock exchanges registered: the Ukrainian Interbank Currency Exchange, the Ukrainian International Stock Exchange, the Kiev International Stock Exchange, the "Innex" Stock Exchange, the "Ukrainian Bourse", the East-European Stock Exchange, the "Perspektiva", the Pridneprovska Stock Exchange and the PFTS Stock Exchange. Such a narrow segmentation and high fragmentation of the national equity market is regarded as reducing its capitalization potential (Zotsenko, 2014).

During 1993-1996, the range of legislative documents promoted the establishment of trust institutions and investment funds[1]. The State Commission on Securities and the Stock Market (currently NCSSM) was founded along with the First Stock Trading System in 1996 (currently PFTS Stock Exchange and appears to be subsidiary of Moscow Interbank Currency Exchange), until 2006 considered as a trading system, and professional associations for depositary and clearing servicing in the market.

Despite such a considerable amount of stock exchanges in Ukraine, just three of them: Perspectiva, PFTS and Ukrainian Stock Exchanges, account for almost 98% of all exchange contracts. Others are not considered to be active in terms of volume and frequency of trading. Moreover, only one of the aforementioned three, the PFTS Stock Exchange, adopts over-the-counter electronic trading system, provides a low cost of trading and more reliable settlement system, which "makes the PFTS the only Ukrainian exchange with daily real market figures" (The Report: Ukraine, 2008, p.53). Until the global financial crisis it served as catalyzer of foreign investment inflow due to its high standards resembling the OTCs of more developed countries.

[1]"On trust institutions" Decree of the Cabinet of Ministers, "Concept of functioning and development of stock market of Ukraine, "Regulations for investment trusts and investment companies"

Therefore, the focus of this work is on the PFTS Stock Exchange, which remains the biggest securities marketplace in Ukraine, accounting for more than 1200 securities listed and a market capitalization of €77 580 million as of 20 April 2016. However, it is still relatively low considering neighboring countries. In addition to trading of the stocks, bonds, state treasury notes, investment certificates, savings certificates and other securities issued in compliance with effective Ukrainian legislation, PFTS also performs the privatization auctions of the State Property Fund of stocks of open joint stock companies. Nevertheless, only open joint stock companies can be listed on PFTS, accounting for 40% of the total trading volume, representing in 2008 around $20-30 billion.

Within the most successful period for PFTS of 2004-2008 the market capitalization had risen 11 times, with year-on-year increases of up to 167%, as well as trading volume significantly going up. In 2007 the benchmark PFTS Index was up a record around 137% in mid-January, which after February with the global financial crisis unfolding, turned into an opposite trend with the Index rapidly falling, and investors selling the stocks to offset losses, like anywhere in the world (The Report: Ukraine, 2008).

However, the volatilities of Ukrainian stock indexes of UX and PFTS were 25,9% and 26,4% correspondingly in 2011 in comparison to DJIA – 4,1% , FTSE - 5,5%, NIKKEI225 – 7,8%.Therefore, Ukrainian stock market, offer a portfolio of highly risky instruments, which is potentially of great interest for speculative investors. Even though Ukrainian stock market is still not integrated into the mainstream international economic system, it is highly dependent on the dynamics of Russian MICEX and RTS stocks, and to a much lower extent on the American S&P500 and DJIA performance; demonstrating as well a strong correlation with gold prices, while to lower extent with the change on silver and crude oil prices ("Riurik", 2011). Figure 1 demonstrates well that indexes PFTS and RTS are highly correlated, both following downward trends and bearing seasonal effects, which is especially apparent relative to the S&P 500 upward and significantly less volatile performance.

While the post-crisis period is of particular interest to examine the market efficiency of the stock market in Ukraine, some particular trends could be considered as positive for

Figure 1- PFTS Index dynamics relative to RTS and S&P 500

Source: Bloomberg Markets

its development: reforms on corporate legislation, in particular, amendments to the Ukrainian Tax Code, the stimulation of trading through over-the-counter transactions, "Joint Stock Companies" Law, the issuance of laws protecting the minority shareholdings; WTO entry on 16 May, 2008, efforts at restoring attractiveness for foreign investors after the financial crisis, the signing of the DEEP and Comprehensive Free Trade Area (DCFTA) on 27 June, 2014 etc. Nevertheless, the Euromaidan protests, starting on 21 November, 2013, the annexation of Crimea, and further escalation of the Russian-Ukrainian conflict significantly raised political risk in the country and resulted in considerable worsening of the economic situation, hence negatively affecting the stock market. In addition, Ukrainian stock market has often been characterized as not sufficiently liquid, which is visible in the small number of traded stocks and in high bid-ask spreads, unreported off-shore transactions, all of this amplified by the gaps in regulation, poor corporate governance, limitations on the listing of companies with small and medium capitalization, distrust of domestic investors etc. (Zotsenko, 2014). These factors might well suggest the potential violation of EMH sufficient conditions.

To sum up, within 25 years of independence of Ukraine, since the beginning the country faced unfavorable economic conditions, which did not incite a successful and rapid capital market development. The privatization process since 1995 has given rise to an organized stock market with regard to securities issuance volume and the participation of domestic and foreign traders. The Ukrainian equity market is quite fragmented, with the PFTS Stock Exchange however being the most liquid and the biggest one in terms of market capitalization. Therefore, PFTS Index can serve as the basis for a potentially meaningful analysis of secondary market stock price behavior.

4. Methodological Aspects

This section clarifies the choice of the methodological approach and describes the data used for empirical research. Besides, it also presents a short overview of the methodological steps to be followed to reach the final results that will be presented.

4.1 Data

To test the weak-form efficiency of Ukrainian stock market, the aforementioned PFTS Stock Exchange benchmark index will be used. It represents twenty stocks of the largest capitalized companies in metallurgy, energy, chemical, banking and telecommunication sectors and usually closely tracked by international financial community (Appendix 23). The sample covers the period from 08/01/2009, the first trading day of that year, till 30/12/2015, therefore, 7 years, with daily frequency (5 days per week) and accounting for 1821 observations. The data on PFTS Stock Index performance, the closing daily stock prices, is derived from official PFTS website.

4.2. Times series analysis with ARIMA - ARCH/ GARCH

The autoregressive integrated moving average (ARIMA) and autoregressive moving average (ARMA) are forecast models based on the variable's past values and errors, also referred to as innovations and shocks (SAS Institute, 2014). The ARIMA approach, known also as Box-Jenkins models, was introduced in 1970 (Makridakis & Hibon, 1997).

An ARMA model is simply a linear combination of AR and MA, an autoregressive and moving average models correspondingly. In AR-component the predictors are the previous values of the series, while in MA-component these are the noise terms. The two aforementioned models stand for an ARMA (p,q) model of order p, q in the form of a linear combination:

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots + \phi_p Y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \ldots - \theta_q \varepsilon_{t-q}, \quad (4.1)$$

where Y_t *- the actual value;*

ε_t *– random error at t (white noise);*

ϕ_2 *and* θ_1*- coefficients*

p and q – integers: autoregressive and moving average.

An ARIMA(p,d,q) implies the same ARMA (p,q) model, but integrated (I) or, in other words, differenced 'd' times, so that the series were stationary. As long as like in the number of statistics and econometrics methods, ARIMA is applied only to the stationary times series: the data properties do not depend on the time at which the series are observed, so that there are no apparent trends and seasonality, affecting the value of the time series at different times (Hyndman & Athanasopoulos, 2014). In statistics, stationarity usually refers to its weak-form definition and implies constant mean and constant variance. While in strict stationarity the probability distribution of the time series does not change over time.

The logarithmic computation of the differences between consecutive observations can help to stabilize the variance of a time series. Therefore, converting non-stationary data into stationary is usually the first step in ARIMA modeling: differencing enables to stabilize the mean of a time series removing changes in the level of the time series, and hence eliminating seasonality and trend (Hyndman & Athanasopoulos, 2014). The widespread method for stationarity check is an augmented Dickie-Fuller test (ADF).

As it was previously mentioned, ARIMA is often used in combination with ARCH/GARCH, autoregressive conditional heteroskedasticity and generalized autoregressive conditional heteroskedasticity models correspondingly. They have become of great application in finance due to their relative interpretation simplicity and interest for volatility clustering, the magnitude of uncertainty in particular models (Engle, 2001). ARCH/GARCH enable to measure the volatility of the series, in particular, to model the noise term of ARIMA based on the conditional variances (Pham, 2013).

Market volatility in the stock markets tends to cluster during the periods of low and periods of high volatility, referred to as heteroskedasticity. As it follows from the name, ARCH/ GARCH models enable modeling the average error size as an autoregressive process. Instead of correcting it, such models treat heteroskedasticity as a variance to be modeled; as a result, the prediction for the variance of each error term is computed and the deficiencies of least squares are corrected (Engle et al., 2007).

The first ARCH model assumed the variance of tomorrow's return to be an equally weighted average of the squared residuals from the preceding period. Therefore, the next step is the estimation and determination of the weights parameters to be used in the variance forecast (Engle, 1982). Further on, GARCH model, introduced by Bollerslev (1986), has enabled to predict the conditional variances. This specification applies to a weighted average of past squared residuals, with the declining weights tending not completely to zero. In general, the subsequent period best predictor of the variance is a weighted average of the long run average variance, the current period predicted variance and the most recent squared residual. Last but not least, ARCH models require "many parameters to describe appropriately the volatility process" of asset returns, while GARCH models need just three, which justifies the preference of economists to use the latter in practice (Matei, 2009, p.51).

The availability of data and improved statistics applications have promoted the development of a vast variety of ARCH/GARCH, among which are IGARCH, EGARCH, MGARCH, GARCH-M, and ACD models. They differentiate relative to the defined function of conditional variance dependent on the lags and lags of the squared residuals.

In general, ARCH (q) can be presented as:

$$\sigma_t^2 = \gamma_0 + \sum_{i=1}^{q} \gamma_i \varepsilon_{t-i}^2, \text{(4.2)}$$

where σ_t^2– *conditional dispersion of residuals or volatility in moment t,*

ε_{t-1} – *lag value of residual in the moment (t-i);*

γ_0– *constant; base volatility;*

q – order of ARCH model, the number of price changes, affecting thepresent volatility;

γ_1– *weights coefficients, defining the degree of influence of preceding residuals values on the present volatility.*

In addition, coefficients estimates γ_0, γ_1, $\delta_j$are supposed to be not negative and standardized residuals $z_t = \frac{\varepsilon_t}{\sigma_t}$ are independent and follow normal distribution.

Accordingly GARCH (q) enables to lower the amount of parameters:

$$\sigma_t^2 = \gamma_0 + \sum_{i=1}^{q} \gamma_i \varepsilon_{t-1}^2 + \sum_{j=1}^{p} \delta_j \sigma_{t-j}^2, \quad (4.3)$$

where *p – the number of preceding estimates of volatility, affecting its present value;*

δ_j– weights coefficients *defining the degree of influence of preceding volatility values on the present value (GARCH-parameters)*

In general, the GARCH models with p=1, q=1 are widely used, more rarely GARCH (1, 2) or GARCH (2,1). In empirical research, ARCH/ GARCH models are extensively applied for testing the hypothesis of weak-form of efficiency.

The following steps will be completed in EViews6.0.to test the weak-form efficiency of PFTS stock market (Lukianenko & Zhuk, 2013).

1. The conversion of index values into logarithmic returns. Check of the time series for stationarity with the use of Dickey-Fuller test. Once the null hypothesis about a unit root presence is rejected, the data is characterized as stationary and can be used further on. This is followed by the check for normal distribution.
2. Choice of the specification of ARMA model: if it fits autoregressive integrated (AR), moving average (MA) or both and, hence, it is mixed. While in some cases the best fit for the data appears to be with both AR and MA components present. Autocorrelation function (ACF) and partial autocorrelation (PACF) plots help to identify the number of AR and MA terms needed, so that any autocorrelation left in the differenced series was corrected. In order to define ARMA-specification, the following *Hennon-Rissanen procedure* will be applied:

   2.1. Firstly, with regard to **AR-specification**, the maximum number of AR-components is identified with the least square method and Akaike criterion. AR-component with the highest p-value should be omitted and new Akaike criterion value is compared with the preceding value. In case it decreases, the same procedure is repeated with the next AR-component; if Akaike criterion value increases, the AR-component is returned and the same procedure with the consequent AR-component with regard to p-value is repeated till the omission of any AR-component leads to an Akaike criterion value increase. In this way, using the smallest number of terms, that fit our data, we are able to minimize the sum of squared errors.

2.2. Secondly, regarding **MA-specification**, the residuals series for the aforementioned specified model are generated. The model will be estimated as optimal AR-component in addition to the lagged residual series. The minimization of Schwarz criterion (SIC, or also known as Bayesian information criterion, BIC) value will enable to identify the optimal model. Lastly, lag values of the residuals are replaced for corresponding MA-components to test the optimal ARMA model.

3. Check for ARCH/ GARCH effect. We will apply the residuals heteroscedasticity ARCH-test and in addition to it, the procedure through the conditional mean equation. Based on the autocorrelogram of PFTS log returns, we run the conditional mean equation to examine if they are statistically significant:

$$\gamma_t = \alpha + u_t, \ (4.4)$$

where γ_t – *log returns;*

u_t – *the error terms*

We include only the constant, since we assume the market is efficient. In case the autocorrelogram indicates on significant autocorrelation presence, several lags will be added and the equation will be the following:

$$y_t = \alpha + \beta y_{t-1} + u_t, \ (4.5)$$

Afterwards, the squared residuals series ($\hat{u}_t^2$) are generated and the auxiliary equation is run to eliminate insignificant lags:

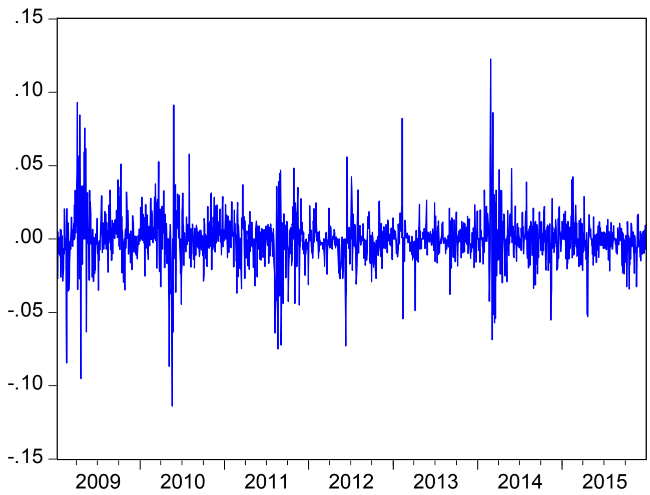
$$\hat{u}_t^2 = \gamma_0 + \gamma_1 \hat{u}_{t-1}^2 + \ldots + \gamma_q \hat{u}_{t-q}^2, \ (4.6)$$

Once all the lags are statistically significant on the 95% confidence level and the coefficient of determination is high, it indicates on the ARCH-effect (Zivot, 2008). Finally, GARCH(1,1) will be applied to model volatility of the series, so that more recent fluctuations and changes in the series were reflected.

5. Empirical Results Discussion

The first step to make the data fit ARMA modeling is the application of the log-difference function to the times series to convert the data into stationary. From Figure 2 we can observe that the variance of the series tends to change, indicating on volatility clustering (MathWorks, 2016). The GARCH model, discussed further on, primarily aims to model this phenomenon (Cont, 2005, p. 290).

Figure 2 – PFTS log returns dynamics, 2009-2015



Based on descriptive statistics and normality check tests we have identified that the time series do not follow the normal distribution. Kurtosis is statistically different from the normal distribution's value; as well as the values of asymmetry and kurtosis due to Jarque- Bera; based on Lilliefors test, the null hypothesis was also rejected (Annexes 2, 3). Augmented Dickey-Fuller test rejected the null hypothesis of a unit root presence, and, therefore, confirmed that the time series are stationary and suitable for the further analysis (Table 3).

ARMA Specification. Next, we look for the autoregressive pattern in the time series at the autocorrelogram of PFTS log returns to identify statistically significant lags, which appear to be 1,2, 4, 8, 9, 10, 15, 17, 29, 30 (Annex 6). Based on Akaike minimization criterion, which is equal to 5.475081, through consistent estimation of AR-components, we have obtained the optimal AR terms at lags 1, 4, 9, 10, 17, 29, 30 (Annexes 7-9).

Table 3 - ADF Unit Root test results for PFTS log returns

	PFTS log returns
t-statistic	-31.40254
Prob*	0.000
Lag length	0, based on SIC
R^2 adj	0.351562
N- observation, after adjustment	1818

Note: Test critical values: on 1% interval – 3.434; on 5% interval – 2.863; on 10% level – 2.567

To identify the optimal MA terms, we generated the residual series for the aforementioned specified AR-model. Based on the autocorrelogram, there are no statistically significant lags; they tend to be the white noise (Annexes 11, 12). Therefore, we proceed with evaluation of ARMA model without MA-component. Table 4 shows the estimated optimal ARMA model.

Table 4 – Optimal AR model based on minimized AIC

Variable	t-Statistic	Prob
C	0.069329	0.9447
AR(1)	12.79745	0.000
AR(4)	1.882836	0.0599
AR(9)	2.344091	0.0192
AR(10)	2.246342	0.0248
AR(17)	2.031497	0.0424
AR(29)	-2.971557	0.0030
AR(30)	1.903016	0.0572
R^2	0.105170	
R^2 adjusted	0.101653	
F-statistic	29.90309	
Prob (F-statistic)	0.00000	
AIC	-5.475081	

The model is stationary, or in other words, dynamically stable, as long as all the roots lie strictly inside the unit circle (Annex 15).

The ARMA model is deemed adequate enough provided that the residuals of the estimated final equation are the white noise. The autocorrelogram of the squared residuals (Annex 13), in comparison to the autocorrelogram of the residuals, has identified no white noise, which indicates on presence of ARCH/ GARCH-effects to be checked further on.

Testing for ARCH/ GARCH-effect. The residuals heteroscedasticity ARCH-test with the hypothesis of no ARCH-effect in the data is rejected, confirming the presence of an ARCH-effect in the data and justifying the need for the GARCH in our model (Annex 16). In addition, through the conditional mean equation we have obtained statistically significant lags and the coefficient of determination equal to 0.97%, that is high enough for this type of models; therefore we conclude that there is ARCH-effect (Annexes 17-21).

GARCH (1,1) model estimation. Since we have found ARCH-effect in the squared residuals of the conditional mean equation for PFTS log returns, GARCH (1,1), usually used in econometrics literature, will be applied. The estimated model's results are presented in Table 5.

Table 5 – GARCH (1, 1) results

Variable	z-Statistic	Prob
C	-1.195116	0.2320
AR(1)	11.16976	0.000
AR(4)	1.149039	0.2505
AR(9)	0.766366	0.4435
AR(10)	0.855151	0.3925
AR(17)	0.889586	0.3737
AR(29)	-1.664096	0.0961
AR(30)	2.100330	0.0357
Variance Equation		
C	7.794779	0.0000
Squared Residuals(-1)	14.10333	0.0000
GARCH(-1)	45.11575	0.0000
R^2	0.098453	
R^2 adjusted	0.093382	
F-statistic	19.41652	
Prob (F-statistic)	0.00000	
AIC	-5.815531	
Durbin-Watson Statistic	2.003686	

The obtained results are the following: on a 5% confidence level, lags 1 and 30 tend to be statistically significant, which implies PFTS returns' dependence in the current period on the lags 1 and 30. In addition, on a 10% confidence level, we can observe statistically significant 1, 29, 30 lags. Therefore, the hypothesis of the weak efficiency of Ukrainian stock market is rejected.

Conclusions and Future Research Suggestions

This study aimed at testing the efficiency of Ukrainian stock market, in particular, its weak-form, using daily PFTS index time series. The relatively short period of its establishment and development along with an apparently not favorable economic situation has not proved to be successful for reaching the same level of development of former communist West-European economies.

In order to examine linear and non-linear dependence in the daily data, ARMA and GARCH, determined through Hennon-Rissanen procedure, were applied. The null hypothesis of the weak-form stock market efficiency during the tested period of 2009-2015 was rejected. The preconditions in the form of significant share of 'shadow' transactions, illiquidity, gaps in the regulation and limited access of S&M firms have initially indicated on the violation of EMH conditions. Therefore, the findings have confirmed this evidence. However, the fact that this study has identified weak-form inefficiency tends to be justified regarding Ukrainian capital markets' underdevelopment in terms of market capitalization and relative infancy.

There is a range of restraining factors related to institutional characteristics that need to be addressed in order to improve the efficiency of the Ukrainian stock market: ineffective reporting standards and presentation of the information on the stock index, inability to obtain full information and, therefore, unequal access of the market participants to the information. Secondly, level of trading transaction costs and unprotected property rights. In addition, there is apparently a need for legislative changes, in particular, to alleviate the complicated procedures of trading in the stock market, foster infrastructure and technology development, and probably improve reporting systems of companies for better monitoring. Last but not least, increase in liquidity could have a favorable impact on improvement of market efficiency.

However, with the European Union Association Agreement about Deep and Comprehensive Free Trade Area, signed on 21 March and 27 June, 2014, Ukraine has taken a pro-European course and obliged to carry out reforms to converge national legislation with European Union's, which would definitely contribute to the financial markets' development. Therefore, within some period of time, the informational efficiency improvement could be anticipated. Consequently, this can serve the basis for future research. Besides, to confirm the findings of this study, investment strategies to obtain abnormal returns in the Ukrainian stock market could be examined further on. However, the most important research area lies in finding out the best legislative solutions to make the regulatory environment effective and the trading place attractive for the investors, both domestic and international.

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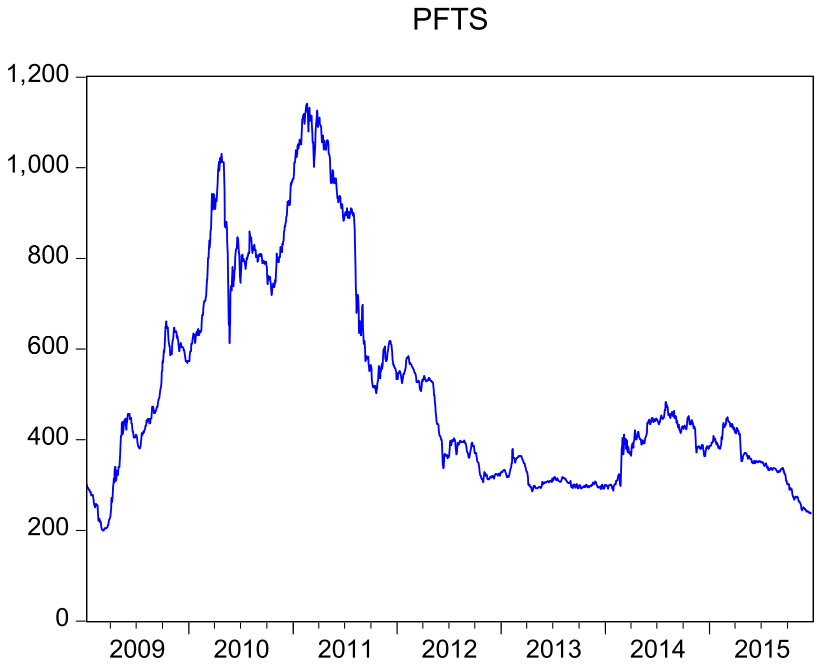
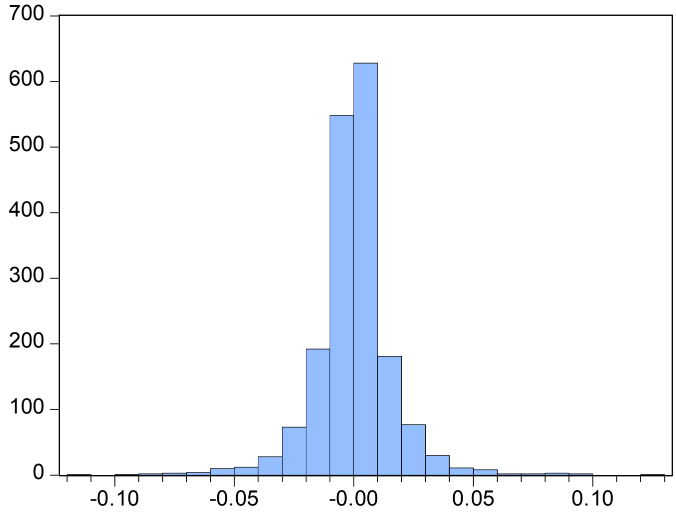
Annexes

Annex 1 – PFTS Index dynamics (2009-2015)



Annex 2 – Descriptive statistic on PFTS



Series: RPFTS	
Sample 1/08/2009 12/30/2015	
Observations 1819	
Mean	-0.000127
Median	1.83e-05
Maximum	0.122645
Minimum	-0.113788
Std. Dev.	0.016610
Skewness	0.062401
Kurtosis	11.14189
Jarque-Bera	5025.437
Probability	0.000000

Annex 3 – Normality tests results

Empirical Distribution Test for RPFTS
Hypothesis: Normal
Date: 06/03/16 Time: 01:58
Sample (adjusted): 1/09/2009 12/30/2015
Included observations: 1819 after adjustments

Method	Value	Adj. Value	Probability
Lilliefors (D)	0.105650	NA	0.0000
Cramer-von Mises (W2)	9.052193	9.054681	0.0000
Watson (U2)	9.051671	9.054159	0.0000
Anderson-Darling (A2)	49.05528	49.07554	0.0000

Method: Maximum Likelihood - d.f. corrected (Exact Solution)

Parameter	Value	Std. Error	z-Statistic	Prob.
MU	-0.000127	0.000389	-0.327012	0.7437
SIGMA	0.016610	0.000275	60.29925	0.0000

Log likelihood	4873.261	Mean dependent var.	-0.000127
No. of Coefficients	2	S.D. dependent var.	0.016610

Annex 4 – Augmented Dickey-Fuller test results for PFTS Index

Augmented Dickey-Fuller Unit Root Test on PFTS

Null Hypothesis: PFTS has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.087197	0.7229
Test critical values:	1% level	-3.433745	
	5% level	-2.862926	
	10% level	-2.567555	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PFTS)
Method: Least Squares
Date: 06/02/16 Time: 21:17
Sample (adjusted): 1/12/2009 12/30/2015
Included observations: 1818 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PFTS(-1)	-0.000964	0.000887	-1.087197	0.2771
D(PFTS(-1))	0.319475	0.022241	14.36428	0.0000
C	0.471078	0.495700	0.950329	0.3421

R-squared	0.102325	Mean dependent var	-0.029873
Adjusted R-squared	0.101336	S.D. dependent var	9.289442
S.E. of regression	8.806196	Akaike info criterion	7.190437
Sum squared resid	140751.6	Schwarz criterion	7.199522
Log likelihood	-6533.107	Hannan-Quinn criter.	7.193789
F-statistic	103.4448	Durbin-Watson stat	1.979493
Prob(F-statistic)	0.000000		

Annex 5 – Augmented Dickey-Fuller test results for the log returns of PFTS

Augmented Dickey-Fuller Unit Root Test on RPFTS

Null Hypothesis: RPFTS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-31.40254	0.0000
Test critical values:	1% level	-3.433745	
	5% level	-2.862926	
	10% level	-2.567555	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RPFTS)
Method: Least Squares
Date: 06/02/16 Time: 21:18
Sample (adjusted): 1/12/2009 12/30/2015
Included observations: 1818 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RPFTS(-1)	-0.703108	0.022390	-31.40254	0.0000
C	-7.43E-05	0.000372	-0.199698	0.8417

R-squared	0.351919	Mean dependent var	1.61E-05
Adjusted R-squared	0.351562	S.D. dependent var	0.019692
S.E. of regression	0.015857	Akaike info criterion	-5.449312
Sum squared resid	0.456623	Schwarz criterion	-5.443255
Log likelihood	4955.424	Hannan-Quinn criter.	-5.447077
F-statistic	986.1196	Durbin-Watson stat	1.979728
Prob(F-statistic)	0.000000		

Annex 6 – Autocorrelogram of PFTS log returns

Correlogram of RPFTS

Date: 06/02/16 Time: 21:18
Sample: 1/08/2009 12/30/2015
Included observations: 1819

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.297	0.297	160.60	0.000
		2	0.060	-0.031	167.17	0.000
		3	0.040	0.034	170.14	0.000
		4	0.059	0.043	176.44	0.000
		5	0.025	-0.006	177.58	0.000
		6	0.029	0.025	179.15	0.000
		7	0.042	0.027	182.33	0.000
		8	0.062	0.043	189.45	0.000
		9	0.092	0.066	204.89	0.000
		10	0.107	0.064	225.78	0.000
		11	0.053	-0.002	230.90	0.000
		12	0.023	0.000	231.83	0.000
		13	0.016	0.000	232.32	0.000
		14	0.032	0.019	234.19	0.000
		15	-0.002	-0.026	234.20	0.000
		16	0.014	0.015	234.58	0.000
		17	0.057	0.042	240.45	0.000
		18	0.037	-0.005	242.95	0.000
		19	0.010	-0.012	243.12	0.000
		20	0.039	0.031	245.95	0.000
		21	0.027	-0.002	247.33	0.000
		22	0.011	-0.001	247.54	0.000
		23	0.004	-0.002	247.58	0.000
		24	-0.003	-0.013	247.59	0.000
		25	0.012	0.013	247.84	0.000
		26	0.049	0.039	252.33	0.000
		27	0.027	-0.009	253.70	0.000
		28	0.007	-0.005	253.80	0.000
		29	-0.052	-0.064	258.75	0.000
		30	0.015	0.042	259.17	0.000
		31	0.026	0.006	260.46	0.000
		32	0.019	0.011	261.12	0.000
		33	-0.019	-0.026	261.76	0.000
		34	-0.000	0.004	261.76	0.000
		35	0.010	0.002	261.93	0.000
		36	-0.015	-0.027	262.35	0.000

Annex 7 – AR-Specification: all the lags included

Dependent Variable: RPFTS
Method: Least Squares
Date: 06/02/16 Time: 21:39
Sample (adjusted): 2/20/2009 12/30/2015
Included observations: 1789 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.46E-05	0.000369	0.066571	0.9469
RPFTS(-1)	0.298176	0.023556	12.65836	0.0000
RPFTS(-2)	-0.032858	0.023299	-1.410294	0.1586
RPFTS(-4)	0.043121	0.022311	1.932767	0.0534
RPFTS(-8)	0.022776	0.023363	0.974864	0.3298
RPFTS(-9)	0.048438	0.024310	1.992550	0.0465
RPFTS(-10)	0.054400	0.023330	2.331733	0.0198
RPFTS(-15)	-0.018679	0.022221	-0.840609	0.4007
RPFTS(-17)	0.044071	0.022275	1.978486	0.0480
RPFTS(-29)	-0.068039	0.023214	-2.931012	0.0034
RPFTS(-30)	0.044490	0.023274	1.911593	0.0561

R-squared	0.106968	Mean dependent var	3.25E-05
Adjusted R-squared	0.101945	S.D. dependent var	0.016488
S.E. of regression	0.015625	Akaike info criterion	-5.473738
Sum squared resid	0.434091	Schwarz criterion	-5.439986
Log likelihood	4907.259	Hannan-Quinn criter.	-5.461275
F-statistic	21.29690	Durbin-Watson stat	1.994380
Prob(F-statistic)	0.000000		

Annex 8 – AR-Specification: lag 15 omitted

Dependent Variable: RPFTS
Method: Least Squares
Date: 06/02/16 Time: 21:39
Sample (adjusted): 2/20/2009 12/30/2015
Included observations: 1789 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.59E-05	0.000369	0.070130	0.9441
RPFTS(-1)	0.297704	0.023547	12.64296	0.0000
RPFTS(-2)	-0.032917	0.023297	-1.412932	0.1579
RPFTS(-4)	0.042188	0.022281	1.893418	0.0585
RPFTS(-8)	0.022274	0.023354	0.953786	0.3403
RPFTS(-9)	0.048260	0.024307	1.985470	0.0472
RPFTS(-10)	0.054147	0.023326	2.321303	0.0204
RPFTS(-17)	0.043060	0.022241	1.936051	0.0530
RPFTS(-29)	-0.068677	0.023199	-2.960308	0.0031
RPFTS(-30)	0.044785	0.023269	1.924677	0.0544

R-squared	0.106613	Mean dependent var	3.25E-05
Adjusted R-squared	0.102093	S.D. dependent var	0.016488
S.E. of regression	0.015624	Akaike info criterion	-5.474459
Sum squared resid	0.434264	Schwarz criterion	-5.443775
Log likelihood	4906.904	Hannan-Quinn criter.	-5.463129
F-statistic	23.58860	Durbin-Watson stat	1.994239
Prob(F-statistic)	0.000000		

Annex 9 – AR-Specification: lags 15 and 8 omitted

Dependent Variable: RPFTS
Method: Least Squares
Date: 06/02/16 Time: 21:38
Sample (adjusted): 2/20/2009 12/30/2015
Included observations: 1789 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.54E-05	0.000369	0.068665	0.9453
RPFTS(-1)	0.298210	0.023540	12.66797	0.0000
RPFTS(-2)	-0.032642	0.023294	-1.401265	0.1613
RPFTS(-4)	0.043315	0.022249	1.946809	0.0517
RPFTS(-9)	0.054965	0.023267	2.362349	0.0183
RPFTS(-10)	0.053269	0.023308	2.285474	0.0224
RPFTS(-17)	0.044716	0.022172	2.016717	0.0439
RPFTS(-29)	-0.068329	0.023196	-2.945757	0.0033
RPFTS(-30)	0.044702	0.023268	1.921175	0.0549

R-squared	0.106156	Mean dependent var	3.25E-05
Adjusted R-squared	0.102138	S.D. dependent var	0.016488
S.E. of regression	0.015623	Akaike info criterion	-5.475066
Sum squared resid	0.434486	Schwarz criterion	-5.447450
Log likelihood	4906.446	Hannan-Quinn criter.	-5.464869
F-statistic	26.42480	Durbin-Watson stat	1.994394
Prob(F-statistic)	0.000000		

Annex 10 – AR-Specification: optimal AR model based on minimized AIC

Dependent Variable: RPFTS
Method: Least Squares
Date: 06/02/16 Time: 21:40
Sample (adjusted): 2/20/2009 12/30/2015
Included observations: 1789 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.56E-05	0.000369	0.069333	0.9447
RPFTS(-1)	0.288789	0.022566	12.79745	0.0000
RPFTS(-4)	0.041857	0.022231	1.882836	0.0599
RPFTS(-9)	0.054551	0.023272	2.344091	0.0192
RPFTS(-10)	0.052350	0.023305	2.246342	0.0248
RPFTS(-17)	0.045053	0.022177	2.031497	0.0424
RPFTS(-29)	-0.068934	0.023198	-2.971557	0.0030
RPFTS(-30)	0.044288	0.023273	1.903016	0.0572

R-squared	0.105170	Mean dependent var	3.25E-05
Adjusted R-squared	0.101653	S.D. dependent var	0.016488
S.E. of regression	0.015628	Akaike info criterion	-5.475081
Sum squared resid	0.434965	Schwarz criterion	-5.450534
Log likelihood	4905.460	Hannan-Quinn criter.	-5.466017
F-statistic	29.90309	Durbin-Watson stat	1.976825
Prob(F-statistic)	0.000000		

Annex 11 – Autocorrelogram of the model's residuals

Correlogram of MA_RES

Date: 06/02/16 Time: 21:43
Sample: 1/08/2009 12/30/2015
Included observations: 1789

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.011	0.011	0.2318	0.630
		2	-0.039	-0.040	3.0133	0.222
		3	0.012	0.013	3.2647	0.353
		4	-0.007	-0.009	3.3510	0.501
		5	-0.015	-0.014	3.7817	0.581
		6	0.018	0.018	4.3609	0.628
		7	0.016	0.015	4.8495	0.678
		8	0.010	0.012	5.0397	0.753
		9	-0.002	-0.001	5.0454	0.830
		10	-0.001	-0.000	5.0471	0.888
		11	0.002	0.003	5.0579	0.928
		12	-0.007	-0.007	5.1393	0.953
		13	-0.009	-0.009	5.2952	0.968
		14	0.028	0.027	6.7334	0.945
		15	-0.017	-0.019	7.2637	0.950
		16	-0.009	-0.006	7.4137	0.964
		17	-0.003	-0.006	7.4339	0.977
		18	-0.005	-0.005	7.4778	0.985
		19	-0.015	-0.014	7.8933	0.988
		20	0.023	0.022	8.8911	0.984
		21	0.007	0.005	8.9857	0.989
		22	-0.005	-0.003	9.0335	0.993
		23	-0.003	-0.003	9.0533	0.996
		24	-0.011	-0.011	9.2885	0.997
		25	-0.001	0.000	9.2916	0.998
		26	0.047	0.047	13.312	0.981
		27	0.016	0.014	13.759	0.984
		28	0.009	0.010	13.892	0.988
		29	0.001	0.001	13.893	0.992
		30	-0.004	-0.003	13.927	0.995
		31	0.004	0.005	13.953	0.996
		32	0.022	0.021	14.864	0.996
		33	0.005	0.005	14.914	0.997
		34	-0.002	-0.004	14.922	0.998
		35	0.007	0.007	15.023	0.999
		36	0.004	0.004	15.046	0.999

Annex 12 – MA-Specification estimates

Dependent Variable: RPFTS
Method: Least Squares
Date: 06/02/16 Time: 21:45
Sample (adjusted): 3/30/2009 12/30/2015
Included observations: 1763 after adjustments

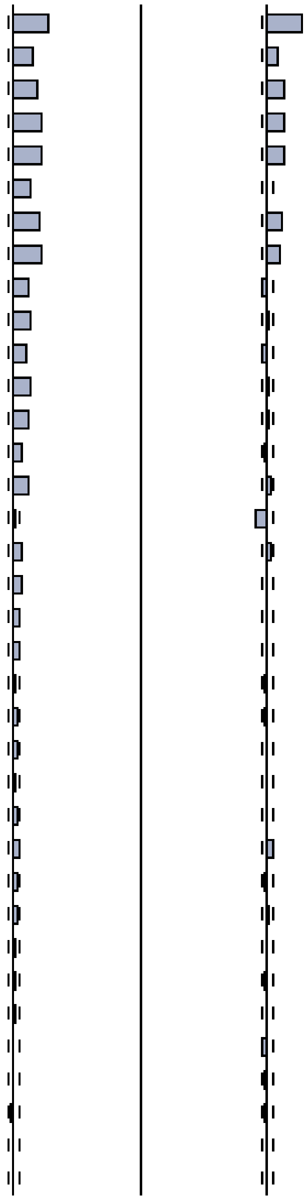
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.79E-05	0.000392	0.096708	0.9230
MA_RES(-2)	0.044341	0.025111	1.765783	0.0776
MA_RES(-26)	0.051053	0.025027	2.039960	0.0415

R-squared	0.004072	Mean dependent var	3.88E-05
Adjusted R-squared	0.002940	S.D. dependent var	0.016498
S.E. of regression	0.016474	Akaike info criterion	-5.372363
Sum squared resid	0.477653	Schwarz criterion	-5.363047
Log likelihood	4738.738	Hannan-Quinn criter.	-5.368921
F-statistic	3.598161	Durbin-Watson stat	1.432801
Prob(F-statistic)	0.027576		

Annex 13 – Autocorrelogram of the model's squared residuals

Correlogram of RES_SQ

Date: 06/03/16 Time: 01:51
Sample: 1/08/2009 12/30/2015
Included observations: 1789



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.291	0.291	151.42	0.000
		2	0.167	0.091	201.70	0.000
		3	0.199	0.142	273.05	0.000
		4	0.237	0.153	373.74	0.000
		5	0.243	0.135	479.41	0.000
		6	0.141	0.004	514.95	0.000
		7	0.211	0.121	595.20	0.000
		8	0.236	0.102	695.28	0.000
		9	0.130	-0.030	725.53	0.000
		10	0.131	0.021	756.64	0.000
		11	0.100	-0.028	774.54	0.000
		12	0.136	0.020	808.04	0.000
		13	0.127	0.016	836.96	0.000
		14	0.075	-0.021	847.12	0.000
		15	0.118	0.032	872.24	0.000
		16	0.021	-0.088	873.07	0.000
		17	0.073	0.027	882.65	0.000
		18	0.072	0.004	891.90	0.000
		19	0.056	0.004	897.60	0.000
		20	0.059	0.001	903.83	0.000
		21	0.018	-0.022	904.42	0.000
		22	0.029	-0.014	905.89	0.000
		23	0.029	-0.001	907.46	0.000
		24	0.018	0.005	908.05	0.000
		25	0.036	0.007	910.46	0.000
		26	0.063	0.055	917.62	0.000
		27	0.033	-0.010	919.61	0.000
		28	0.033	0.018	921.60	0.000
		29	0.011	-0.008	921.83	0.000
		30	0.013	-0.020	922.13	0.000
		31	0.010	-0.006	922.30	0.000
		32	-0.001	-0.026	922.30	0.000
		33	-0.000	-0.016	922.30	0.000
		34	-0.010	-0.022	922.48	0.000
		35	-0.006	-0.006	922.54	0.000
		36	-0.000	0.003	922.54	0.000

Annex 14 – Optimal AR model

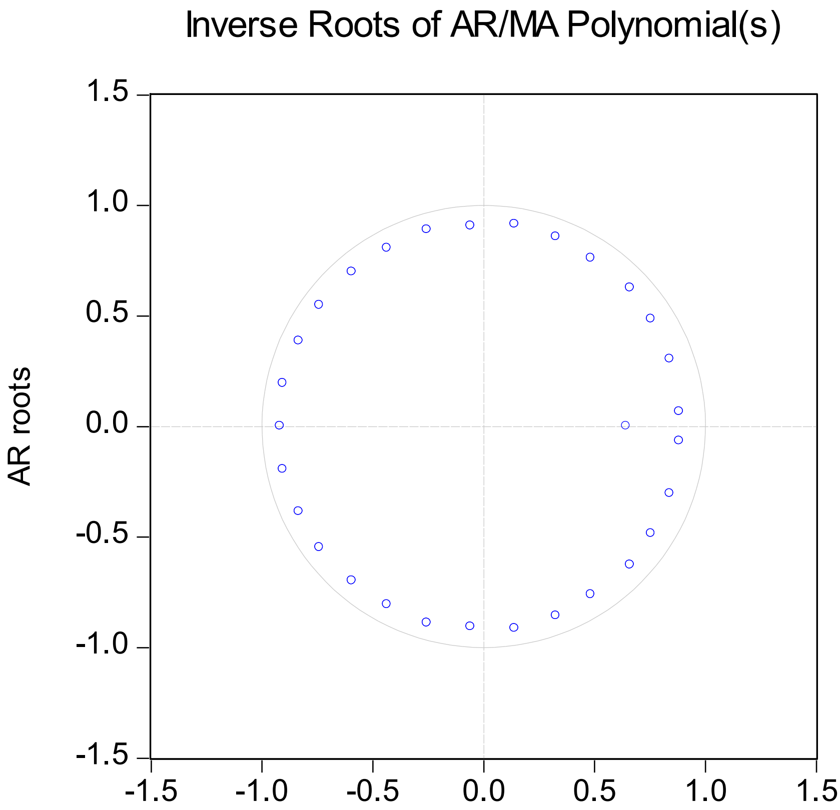
Dependent Variable: RPFTS
Method: Least Squares
Date: 06/02/16 Time: 21:47
Sample (adjusted): 2/20/2009 12/30/2015
Included observations: 1789 after adjustments
Convergence achieved after 3 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.73E-05	0.000682	0.069329	0.9447
AR(1)	0.288789	0.022566	12.79745	0.0000
AR(4)	0.041857	0.022231	1.882836	0.0599
AR(9)	0.054551	0.023272	2.344091	0.0192
AR(10)	0.052350	0.023305	2.246342	0.0248
AR(17)	0.045053	0.022177	2.031497	0.0424
AR(29)	-0.068934	0.023198	-2.971557	0.0030
AR(30)	0.044288	0.023273	1.903016	0.0572

R-squared	0.105170	Mean dependent var	3.25E-05
Adjusted R-squared	0.101653	S.D. dependent var	0.016488
S.E. of regression	0.015628	Akaike info criterion	-5.475081
Sum squared resid	0.434965	Schwarz criterion	-5.450534
Log likelihood	4905.460	Hannan-Quinn criter.	-5.466017
F-statistic	29.90309	Durbin-Watson stat	1.976825
Prob(F-statistic)	0.000000		

Inverted AR Roots	.88-.07i	.88+.07i	.84+.30i	.84-.30i
	.76-.49i	.76+.49i	.66+.63i	.66-.63i
	.64	.48-.76i	.48+.76i	.33-.86i
	.33+.86i	.14+.91i	.14-.91i	-.06-.91i
	-.06+.91i	-.26-.89i	-.26+.89i	-.43-.81i
	-.43+.81i	-.59-.70i	-.59+.70i	-.74+.55i
	-.74-.55i	-.83+.39i	-.83-.39i	-.90+.19i
	-.90-.19i	-.92		

Annex 15 – Inverse Roots Diagram: model's check for stationarity



Annex 16 – The residuals' heteroscedasticity ARCH-test

Heteroskedasticity Test: ARCH

F-statistic	112.7208	Prob. F(1,1787)	0.0000
Obs*R-squared	106.1512	Prob. Chi-Square(1)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 06/02/16 Time: 21:49
Sample: 2/20/2009 12/30/2015
Included observations: 1789

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000191	1.78E-05	10.74322	0.0000
RESID^2(-1)	0.204958	0.019305	10.61701	0.0000

R-squared	0.059335	Mean dependent var	0.000243
Adjusted R-squared	0.058809	S.D. dependent var	0.000745
S.E. of regression	0.000722	Akaike info criterion	-11.62661
Sum squared resid	0.000933	Schwarz criterion	-11.62047
Log likelihood	10402.00	Hannan-Quinn criter.	-11.62434
F-statistic	112.7208	Durbin-Watson stat	1.844953
Prob(F-statistic)	0.000000		

Annex 17 – ARCH-effects testing: conditional mean equation

Dependent Variable: RPFTS
Method: Least Squares
Date: 06/03/16 Time: 01:52
Sample (adjusted): 1/12/2009 12/30/2015
Included observations: 1818 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-7.43E-05	0.000372	-0.199698	0.8417
RPFTS(-1)	0.296892	0.022390	13.25995	0.0000

R-squared	0.088274	Mean dependent var	-0.000112
Adjusted R-squared	0.087772	S.D. dependent var	0.016602
S.E. of regression	0.015857	Akaike info criterion	-5.449312
Sum squared resid	0.456623	Schwarz criterion	-5.443255
Log likelihood	4955.424	Hannan-Quinn criter.	-5.447077
F-statistic	175.8264	Durbin-Watson stat	1.979728
Prob(F-statistic)	0.000000		

Annex 18 – ARCH-effects testing: autocorrelogram of the squared residuals of conditional mean equation

Correlogram of RES_CM2

Date: 06/03/16 Time: 01:53
Sample: 1/08/2009 12/30/2015
Included observations: 1818

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.285	0.285	148.38	0.000
		2	0.163	0.089	197.05	0.000
		3	0.220	0.167	285.58	0.000
		4	0.237	0.144	387.76	0.000
		5	0.239	0.133	491.67	0.000
		6	0.131	-0.008	522.81	0.000
		7	0.201	0.110	596.71	0.000
		8	0.231	0.098	694.53	0.000
		9	0.142	-0.006	731.18	0.000
		10	0.134	0.019	764.25	0.000
		11	0.111	-0.015	786.95	0.000
		12	0.140	0.023	823.03	0.000
		13	0.117	0.001	848.11	0.000
		14	0.066	-0.028	856.17	0.000
		15	0.123	0.041	883.96	0.000
		16	0.016	-0.101	884.44	0.000
		17	0.080	0.040	896.20	0.000
		18	0.074	0.001	906.20	0.000
		19	0.053	0.004	911.36	0.000
		20	0.063	0.005	918.60	0.000
		21	0.015	-0.025	918.99	0.000
		22	0.028	-0.017	920.45	0.000
		23	0.038	0.008	923.07	0.000
		24	0.017	-0.001	923.61	0.000
		25	0.035	0.008	925.85	0.000
		26	0.063	0.056	933.23	0.000
		27	0.036	-0.008	935.58	0.000
		28	0.035	0.018	937.81	0.000
		29	0.013	-0.009	938.10	0.000
		30	0.011	-0.025	938.34	0.000
		31	0.014	0.002	938.70	0.000
		32	0.026	0.003	939.95	0.000
		33	0.036	0.020	942.36	0.000
		34	0.027	0.006	943.71	0.000
		35	0.012	-0.012	943.97	0.000
		36	0.011	-0.004	944.19	0.000

Annex 19 – ARCH-effects testing: Auxiliary regression

Dependent Variable: RES_CM2
Method: Least Squares
Date: 06/03/16 Time: 01:56
Sample (adjusted): 2/03/2009 12/30/2015
Included observations: 1802 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.22E-05	1.94E-05	4.738548	0.0000
RES_CM2(-1)	0.193866	0.023254	8.336878	0.0000
RES_CM2(-2)	0.007095	0.023674	0.299681	0.7645
RES_CM2(-3)	0.102110	0.023643	4.318885	0.0000
RES_CM2(-4)	0.096008	0.023731	4.045688	0.0001
RES_CM2(-5)	0.117183	0.023281	5.033346	0.0000
RES_CM2(-7)	0.089685	0.023344	3.841835	0.0001
RES_CM2(-8)	0.112809	0.023735	4.752772	0.0000
RES_CM2(-16)	-0.085319	0.022284	-3.828654	0.0001

R-squared	0.172512	Mean dependent var	0.000252
Adjusted R-squared	0.168820	S.D. dependent var	0.000776
S.E. of regression	0.000707	Akaike info criterion	-11.66484
Sum squared resid	0.000897	Schwarz criterion	-11.63739
Log likelihood	10519.02	Hannan-Quinn criter.	-11.65471
F-statistic	46.72480	Durbin-Watson stat	1.986466
Prob(F-statistic)	0.000000		

Annex 20 – ARCH-effects testing: Auxiliary regression

Dependent Variable: RES_CM2
Method: Least Squares
Date: 06/03/16 Time: 01:56
Sample (adjusted): 2/03/2009 12/30/2015
Included observations: 1802 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.28E-05	1.93E-05	4.800648	0.0000
RES_CM2(-1)	0.195362	0.022706	8.604138	0.0000
RES_CM2(-3)	0.103552	0.023142	4.474609	0.0000
RES_CM2(-4)	0.096002	0.023725	4.046473	0.0001
RES_CM2(-5)	0.118033	0.023102	5.109221	0.0000
RES_CM2(-7)	0.090772	0.023055	3.937125	0.0001
RES_CM2(-8)	0.112613	0.023720	4.747539	0.0000
RES_CM2(-16)	-0.085404	0.022277	-3.833750	0.0001

R-squared	0.172470	Mean dependent var	0.000252
Adjusted R-squared	0.169241	S.D. dependent var	0.000776
S.E. of regression	0.000707	Akaike info criterion	-11.66590
Sum squared resid	0.000897	Schwarz criterion	-11.64150
Log likelihood	10518.98	Hannan-Quinn criter.	-11.65690
F-statistic	53.41404	Durbin-Watson stat	1.989362
Prob(F-statistic)	0.000000		

Annex 21 – Heteroscedasticity ARCH-effects test

Heteroskedasticity Test: ARCH

F-statistic	17.59520	Prob. F(1,1799)	0.0000
Obs*R-squared	17.44415	Prob. Chi-Square(1)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 06/03/16 Time: 01:57
Sample (adjusted): 2/04/2009 12/30/2015
Included observations: 1801 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.49E-07	9.75E-08	4.608532	0.0000
RESID^2(-1)	0.098417	0.023462	4.194664	0.0000

R-squared	0.009686	Mean dependent var	4.98E-07
Adjusted R-squared	0.009135	S.D. dependent var	4.13E-06
S.E. of regression	4.11E-06	Akaike info criterion	-21.96663
Sum squared resid	3.03E-08	Schwarz criterion	-21.96053
Log likelihood	19782.95	Hannan-Quinn criter.	-21.96438
F-statistic	17.59520	Durbin-Watson stat	2.006388
Prob(F-statistic)	0.000029		

Annex 22 – GARCH(1,1) estimation results

Dependent Variable: RPFTS
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 06/02/16 Time: 21:50
Sample (adjusted): 2/20/2009 12/30/2015
Included observations: 1789 after adjustments
Convergence achieved after 21 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(9) + C(10)*RESID(-1)^2 + C(11)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.000572	0.000479	-1.195116	0.2320
AR(1)	0.306688	0.027457	11.16976	0.0000
AR(4)	0.026881	0.023395	1.149039	0.2505
AR(9)	0.016291	0.021257	0.766366	0.4435
AR(10)	0.019800	0.023154	0.855151	0.3925
AR(17)	0.015176	0.017059	0.889586	0.3737
AR(29)	-0.029646	0.017815	-1.664096	0.0961
AR(30)	0.040822	0.019436	2.100330	0.0357
		Variance Equation		
C	1.40E-05	1.80E-06	7.794779	0.0000
RESID(-1)^2	0.194072	0.013761	14.10333	0.0000
GARCH(-1)	0.752634	0.016682	45.11575	0.0000

R-squared	0.098453	Mean dependent var	3.25E-05
Adjusted R-squared	0.093382	S.D. dependent var	0.016488
S.E. of regression	0.015699	Akaike info criterion	-5.815531
Sum squared resid	0.438230	Schwarz criterion	-5.781778
Log likelihood	5212.992	Hannan-Quinn criter.	-5.803068
F-statistic	19.41652	Durbin-Watson stat	2.003686
Prob(F-statistic)	0.000000		

Inverted AR Roots	.89	.86+.17i	.86-.17i	.82-.34i
	.82+.34i	.74+.51i	.74-.51i	.63+.64i
	.63-.64i	.47-.76i	.47+.76i	.31-.85i
	.31+.85i	.12-.90i	.12+.90i	-.07-.90i
	-.07+.90i	-.26+.87i	-.26-.87i	-.43+.79i
	-.43-.79i	-.59-.68i	-.59+.68i	-.73+.54i
	-.73-.54i	-.82+.38i	-.82-.38i	-.89+.19i
	-.89-.19i	-.90		

Annex 23 – PFTS Index composites (as on Jan. 15 – Apr. 14, 2016)

#	Code	Issuer	Industry	Free Float, %
1	ALMK	Alchevsk Metallurgical Plant	Basic Materials	3.87
2	AVDK	Avdiivka Cokery Plant	Basic Materials	8.19
3	AZST	Azovstal Iron and Steel Works	Basic Materials	3.78
4	BAVL	Raiffeisen Bank Aval	Finance	3.55
5	CEEN	Centerenergo	Utilities	21.71
6	DNEN	Dniproenergo	Utilities	1.89
7	DOEN	Donbasenergo	Utilities	14.14
8	ENMZ	Enakievo Metallurgical Plant	Basic Materials	9.24
9	KVBZ	Krukivsky Carriage Works	Industrials	2.00
10	MSICH	Motor Sich	Industrials	5.83
11	MZVM	Mariupol Heavy Machine Building Plant	Industrials	20.00
12	NITR	INTERPIPE Nyzhnodniprovsky Tube-Rolling Plant	Basic Materials	2.66
13	PGOK	Poltava Ore Mining and Processing Plant	Basic Materials	0.55
14	STIR	Stirol	Basic Materials	9.25
15	SVGZ	Stahanov Car Production Facility	Industrials	8.00
16	UNAF	Ukrnafta	Oil & Gas	8.00
17	USCB	Ukrsotsbank	Finance	0.19
18	UTLM	Ukrtelecom	Telecommunications	7.14
19	YASK	Yasynivka Cokery Plant	Basic Materials	8.65
20	ZAEN	Zakhidenergo	Utilities	2.76